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Chapter 17

The CORONA Satellite Program and the Beginnings of Reconnaissance Satellites*

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Abstract

The time following the Second World War brought significant international tensions and a demand to acquire what was then sensitive information about other countries' activities. In June 1959, the United States responded to this need by beginning the CORONA Reconnaissance Satellite program, only a year after the first US satellite, Explorer I, was launched into space. As the first reconnaissance satellites, the project code named CORONA served the ground-breaking purpose of gathering intelligence information from orbit by producing stereoscopic satellite photography using a special 70 millimeter film developed for use in space. From around 150 to 480 kilometers above Earth, the satellites were able to capture images of areas approximately 7.5 meters in diameter, with image resolution improving to as little as 1.8 meters over the record-setting 145 missions. This information—more specifically, images of the Soviet Union, China, and their allies to include pictures of the Soviet intercontinental ballistic missile launch sites, missile testing ranges, and strategic force deployment—was delivered back to the United States by the utilization of multiple reentry vehicles called "film-buckets," which were recovered over Hawaii with C-119 "Flying

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Boxcars" flown by the US Air Force—a first in the space industry. Although the program ended in 1972, the United States did not admit to the use of reconnaissance satellites until 1978. The images of the 13-year, $132 million project were a well-kept secret until 1995 when US President Bill Clinton signed an executive order to declassify several of the photos taken by CORONA satellites as well as more information about the program. This chapter will discuss the history of the program, development of the satellite technology, as well as the recovery of the intelligence information from the birth of CORONA in 1959 to the program's termination in 1972. The chapter will also include a personal interview with retired US Air Force pilot, Colonel D. B. Parker, who flew several recovery missions for CORONA.

The Beginnings

Discoverer XIII

In August 1960, US President, Dwight D. Eisenhower, announced to the public that a capsule containing an American flag from the Discoverer XIII had successfully been recovered after reentering Earth's atmosphere. Little did the world know that this was not merely a science experiment as the American government told the public but rather it was a cover for a project much bigger: the CORONA reconnaissance satellite program. The idea of CORONA was conceived during a period in history when significant international tensions—particularly between the United States and the Soviet Union—brought a division defined by Winston Churchill as the Iron Curtain, which made it nearly impossible to gather intelligence about the activities in which other countries might be engaged. From the desire to covertly acquire the then sensitive information came forth the American satellite program of CORONA which during its time became the first to use stereoscopic photography to record images from low Earth orbit, the first to use reentry capsules, and the first to be recovered in mid-air as it reentered the atmosphere. Just three short years after the Soviet-made satellite Sputnik achieved orbit, this groundbreaking program not only flourished thanks to the partnership of multiple companies and government agencies but it also grew in to one of the United States' greatest technological achievements of the Space Race.

Figure 17–1: President Eisenhower and the flag from Discoverer XIII.[1]

The Partnerships

Soon after the launch of Sputnik in October 1957, the race to produce a spy satellite began. In order to build such a satellite, a series of partnerships needed to be formed. The Ballistic Missile Division (BDM) of the Air Force headed by Major General Bernard A. Schriever partnered with Richard Bissel and the CIA to jointly manage the CORONA project.

Figure 17–2: General Bernard A. Schriever, head of the US Air Force Ballistic Missile Division, played a significant role of ICBM development and the CORONA program.[2]

This combination coordinated a team that consisted of General Electric, Lockheed Missiles & Space Company, Douglas Aircraft, as well as Eastman Kodak. The roles of these corporations were pivotal in the production of the satellite and the Thor boosters that would launch the satellites into orbit. For example, General Electric was brought on to the team to develop the recovery capsule; Lockheed was contracted for a broad spectrum of roles to include developing the orbiting upper stage that housed the CORONA and integration of the systems for test, launch, and on-orbit operations; Douglas Aircraft was contracted for the Thor boosters; Eastman Kodak was crucial in developing the film used on the satellite.[3] While these companies were all important to the development of the CORONA project, the decision to bring the brand new American company, Itek, into the partnership proved to be quite valuable.

The Value of Itek

In the fall of 1957, Richard Leghorn of Itek found himself in the position of personal adviser to Richard Bissell from the Scientific Engineering Institute (SEI) which was a front for a division of the CIA. Bissell told Leghorn that there was now an interest in satellites that could take pictures from space, more specifically, a film recovery satellite. During one of his first press releases, Leghorn announced that Itek had begun a research and development (R&D) group whose goal was to create information processing equipment but made no mention of the Air Force and CIA. Shortly thereafter, Itek was offered ownership of the Boston University Physical Research Laboratory (BUPRL) which housed 100 or more scientists who specialized in gathering and analyzing intelligence.[4] This meant that rather than spending several years building an efficient research group, Itek gained possession of one overnight. BUPRL recognized the importance of the camera to reconnaissance and was the first to begin investigating the relationship between the performance of intelligence and reconnaissance systems, the effects of atmospheric turbulence on aerial reconnaissance photography, and the psychological factors influencing the interpretation of the photos. It was then that the top secret project Genetrix was created resulting in the first concept for the satellite camera. The point of Genetrix was to mount a spy camera underneath a high-altitude balloon and float the balloon over Soviet territory at approximately 30,480 meters in altitude. Since clear images are crucial for effectively gathering intelligence, it was immediately recognized that a flaw in Genetrix was that the instability of the camera during flight would significantly decrease image resolution.

Figure 17–3: Project Genetrix balloon launch.[5]

Walt Levison designed the revolutionary HYAC camera—HYAC means high activity camera—for the Genetrix project. The camera contained a lens that could pivot in a 120-degree arc and recorded the image on 5-centimeter wide film. As the lens swept back, the film would advance and would then be ready for the next image. Since Itek owned the BUPRL, it owned the HYAC camera design. The Itek camera would be a step forward in the process of developing the CORONA satellite when it was engaged later in the program.

The Flights of CORONA

The First Flight

President Eisenhower formally endorsed the CORONA program in February 1958 and the first successful CORONA flight took place that August, returning the first image of an intelligence target taken from space. With the highest resolution of approximately 7.62 meters in diameter, the first CORONA picture was of the Mys Shmidta Air Field in the Soviet Union, only about 644 kilometers from Nome, Alaska.

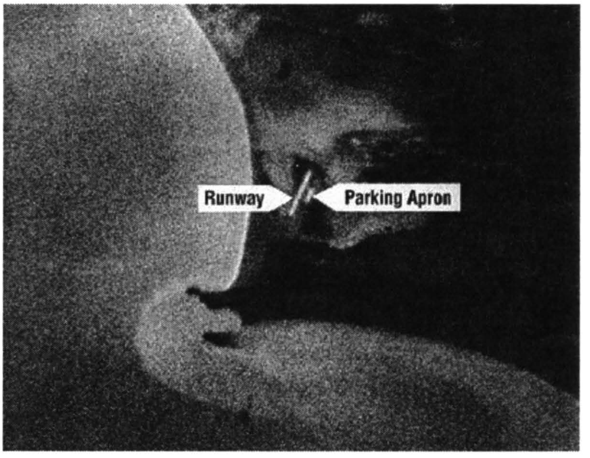

Figure 17–4: The first CORONA image of Mys Shmidta Air Field, a Soviet bomber base.[6]

This first CORONA flight recorded images of over 4,273,480 square kilometers of the Soviet Union on 914.4 meters of film, more than all of the U2 flyovers combined up to that point in history.[7] As the just over a decade of CORONA operations progressed, so did the resolution of the images and the technologies used.

Keyhole Cameras

The early CORONA satellites were designated as Keyhole (KH) 1 and 2, which mainly referred to the cameras on board the spacecraft. The first cameras were panoramic and were actually developed by Fairchild Corporation. The initial resolution of these cameras was between 7.62 and 12.1 meters in diameter. Less than 50 percent of the images returned by the KH-1 and 2 cameras was usable. These early cameras used an acetate-based film and returned with streaks across the images attributed to electrostatic discharges. Developers changed the film rollers to reduce the electrostatic build up and later the film was produced from polyester, which reduced the thickness and weight, allowing for more of it to be carried to orbit, thus increasing mission duration to four or more days.

The cameras produced by Itek, KH-3 and KH-4, were implemented later in 1962 and proved to be valuable changes in the design as the 60.96-centimeter focal length camera was now insulated from thermal impacts of space, controls were more reliable, and a quicker lens system was utilized. It was the KH-4 that first began stereoscopic photography. KH-4 contained two panoramic cameras that greatly increased the ability of the satellite to gather intelligence and extended the duration of the missions to approximately a week.

The KH-4A developed as a result of the success of the KH-4 camera system.

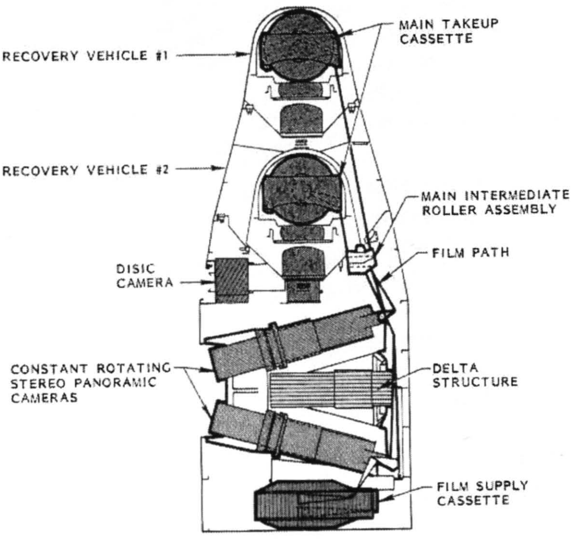

Figure 17–5: Diagram of the KH-4A.[8]

It contained the same cameras as the KH-4 however it dramatically increased the area covered to 46,619,800 square kilometers of territory due to a second film reel and recovery bucket.[9] The resolution of the KH-4A was up to 3 meters in diameter and very reliable compared to previous camera systems. The system also contained an extra camera that kept its sights set on surrounding stars to ensure proper orientation of the reconnaissance cameras and was known as the Dual Improved Stellar Index Camera (DISIC). The KH-4B continued the improvements of the intelligence image resolution—it produced images of resolution between 1.5 meters and 1.8 meters in diameter. These cameras maintained the 60.96-centimeter focal length but Itek situated the cameras so they were "looking" in opposite directions, increasing the ability of the cameras to acquire pictures of intelligence targets. Unlike its predecessors, the KH-4B was able to utilize different types of film which had been developed by Kodak. The KH-4B was the lowest orbiting CORONA at 148 kilometers whereas previous systems operated at about 278 kilometers.

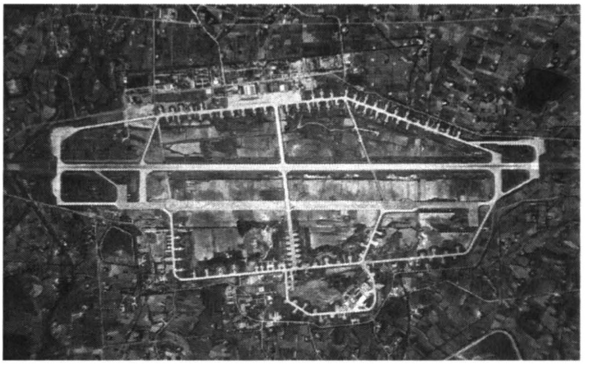

Figure 17–6: CORONA image of Taoyuan Air Force Base, Taiwan, taken in the 1960s.[10]

Spin Stabilization and Itek's Proposal

With the initial KH-1 and KH-2 camera systems, there arose the issue of how to stabilize the satellite so the resolution of the image would provide useable intelligence information. The first CORONA satellites were spin-stabilized so that the satellite would revolve around its axis. Richard Leghorn of ITEK realized in 1957 that this would not be a sufficient solution to the problem.[11] Leghorn introduced Massachusetts Institute of Technology graduate Jack Herther to the Itek team, and it was Herther who proposed the then untested method of three-axis stabilization. Herther's three-axis stabilization technique was incorporated into later versions of the CORONA and was the first satellite with this feature. Later satellites, including Voyager 1 and 2, followed suit.

Recovery

Satellite in Orbit

CORONA satellites were launched to orbit by a Thor booster with an Agena upper stage produced by Lockheed Missiles & Space Company.

Once in orbit, the CORONA would actually orbit backward, or with the nose of the capsule pointed to the rear, to properly orient the cameras for gathering intelligence. Once the CORONA accomplished its mission, the film bucket was ejected from the nose of the orbiting Agena over Alaska and fell to the recovery zone near Hawaii. There, a group of US aircraft, Navy ships, and up to 500 crew members awaited the recovery capsule. Initially, the Air Force flew the C-119 "Flying Boxcar" for the recoveries.

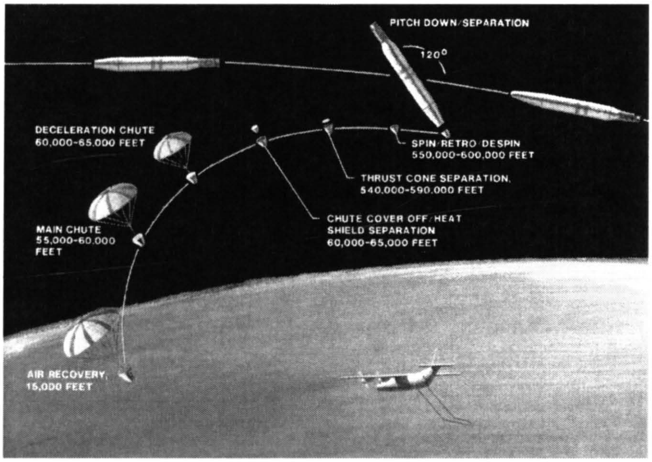

Figure 17–7: CORONA recovery sequence. The CORONA was ejected over Alaska and the parachute deployed between 15–18 kilometers in altitude.[12]

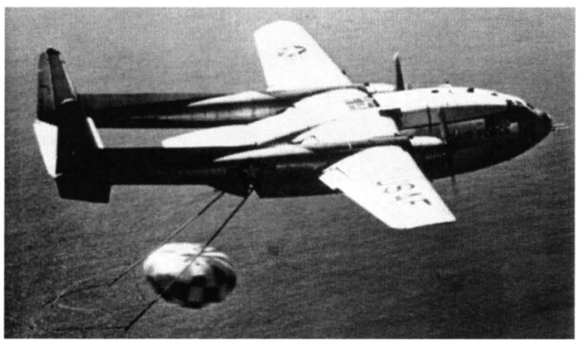

Figure 17–8: A C-119 "Flying Boxcar" catching a CORONA film bucket near Hawaii.[13]

This aircraft was equipped with a large hook that would trail out of the rear of the plane. The crew of the plane would spot the descending capsule and parachute at approximately 4.5 kilometers[14] in altitude. The first pass made by the aircraft would be to gauge the descent rate of the film bucket. The second pass required the C-119 to match the descent velocity of the capsule as it made the first attempt to hook the parachute. If the C-119 was unable to successfully recover the capsule, the next aircraft would have a chance at retrieving it. Should the capsule splash down in the ocean, a US Air Force Pararescue unit was waiting nearby with diving equipment to recover the capsule where it would be taken on board a waiting Navy ship. Retired Colonel D. B. Parker was a pilot in the Air Force recovery squadron stationed in Hawaii from 1964 to 1967. For the first six months, he flew as a copilot before he began training as a Recovery Aircraft Commander (RAC), a role he assumed during the 10th month of his rotation. During an interview he said:

> I feel like doing that was the most important thing I did for my country the entire time I was in the Air Force. We never knew exactly what information was in the capsule but we did know the images were crucial for our president to make diplomatic decisions during the Cold War.

After Colonel Parker's three-year tour as a RAC, he was transferred to Edwards Air Force Base in California where he was assigned to the unit that tested the existing equipment for the program as well as new equipment such as parachutes. He said that after about six years of involvement in the CORONA program he feels "very honored to have been a pilot in that program."

Figure 17–9: A C-130 "Hercules" retrieving a CORONA capsule.[15]

Legacy of CORONA

End of CORONA and the Beginnings of a New Era

The last CORONA flight took place in 1972, although the program was not declassified until 1995 by President Clinton. From 1958 to the termination of the project, CORONA satellites completed a record-setting 145 missions and recorded images of over 1.5 billion square kilometers of Earth's surface. After the retirement of the CORONA satellites, other satellites were developed to take its place.

Figure 17–10: This image illustrates the areas recorded by a KH-4A over a four-day mission, specifically mission 1017.[16]

The KH-9 and KH-11 satellites have continued the work of CORONA. The KH-9 "Big Bird" utilized two stereo cameras and was about three times larger than any of the CORONA satellites. It was equipped to carry four film buckets that were ejected similarly to the CORONA capsules and recovered in midair. From the time between 1971 and 1986, the 19 KH-9 satellites developed an image resolution of up to 15 centimeters in diameter.[17] The duration of the KH-9 missions exceeded that of the CORONA as one of the KH-9 satellites remained in operation for 270 days. The next satellite in the continuation of the Keyhole satellite program was the KH-11 "Kennan." This enormous satellite is cylindrical in shape and about 12 meters long with a diameter of approximately 3 meters. Unlike its ancestors, the KH-11 has what is described as a fold of mirrors, similar to that found in a reflector telescope. There is also a main mirror at 3.7 meters diameter. This system depends on light, entering the KH-11 through a "port" in the side of the satellite, which hits a flat mirror at a 90-degree angle. The image is then reflected on a smaller mirror. A sensor on board the satellite scans the information, which is then sent to Earth by way of a communications satellite. The KH-11 was one of the first satellites to transmit images real time from space and one of the first to produce an image with high enough resolution to read a street sign or a license plate on a car.

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References

[1] "Gaining the High Ground," National Reconnaissance Office, 1997. Web. 1 August 2012. <http://www.nrojr.gov/teamrecon/res_his-Highgrnd.html>.

[2] David Stout, "Gen. Bernard Schriever, 94, Air Force Missile Chief, Dies," *New York Times*, 2005. Web. 1 August 2012. <http://www.nytimes.com/2005/06/24/politics/24schriever.html?_r=1>.

[3] Robert A. McDonald, "CORONA: Success for Space Reconnaissance, A Look in to the Cold War, and a Revolution for Intelligence," *Photogrammetric Engineering & Remote Sensing*, Vol. 61, No. 6 (June 1995), p. 693. Print.

[4] Johnathan E. Lewis, *Spy Capitalism: Itek and the CIA* (New Haven, Connecticut: Yale University Press, 2002), p. 55. Print.

[5] Steve Blank, "Balloon Wars," N.p., 2010. Web. 1 August 2012. <http://steveblank.com/2010/01/28/balloon-wars/>.

[6] Ed Grabianowski, "How Spies Work," N.p., 2011. Web. 5 August 2012. <http://people.howstuffworks.com/spy.htm>.

[7] Robert Mulcahy, "Aviation History: Catching Space Capsules," *Private Pilot* (May 2003), p.73. Print.

[8] Paul R. Baumann, "History of Remote Sensing, Satellite Imagery, Part II," n.p., 2009. Web. 7 August 2012. <http://www.oneonta.edu/faculty/baumanpr/geosat2/RS%20History%20II/RS-History-Part-2.html>.

[9] Robert A. McDonald, "CORONA: Success for Space Reconnaissance, A Look in to the Cold War, and a Revolution for Intelligence," *Photogrammetric Engineering & Remote Sensing*, Vol. 61, No. 6 (June 1995), p. 695. Print.

[10] "U-2 Operations: Images," Taiwan Air Power, 2005. Web. 8 August 2012. <http://www.taiwanairpower.org/u2/images.html>.

[11] Johnathan E. Lewis, *Spy Capitalism: Itek and the CIA* (New Haven, Connecticut: Yale University Press, 2002), p. 56. Print.

[12] "Corona Recovery Sequence," US Centennial Of Flight Commission, 2003. Web. 1 August 2012. <http://www.centennialofflight.gov/essay/SPACEFLIGHT/recon/SP38G4.htm>.

[13] "Gaining the High Ground," National Reconnaissance Office, 1997. Web. 1 August 2012. <http://www.nrojr.gov/teamrecon/res_his-Highgrnd.html>.

[14] Will Hilbrink, "Capsule Alley" Lockheed Missiles & Space Company, *Trajectory* (1961), pp. 35–38. Print.

[15] "Lockheed Martin First Photo Recon SatImage Anniversary (Imagery)," *Satnews*. n.p., 2005. Web. 8 August 2012. <http://www.satnews.com/cgi-bin/story.cgi?number=103670338>.

[16] Jason Ur, "Agriculture and Pastoral Landscapes in the Near East," N.p., 2007. Web. 9 August 2012. <http://www.archatlas.org/workshop/Ur07.php>.

[17] Bill Sweetman, "Spies in the Sky," *Popular Science* (April 1997), pp. 43–48. Print.